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Upper Colville River Channel Depth Survey July 1979

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CONTENTS

FIGURES

TABLES

ABSTRACT

River channel depths of the upper Colville River were surveyed during a float trip in late July, 1979. The entire float traversed 152 kilometers of river. Forty-nine kilometers of continuous river channel depth recordings were used to calculate that 23 percent of the river was riffle, 57 percent was greater than riffle depth yet less than 2 meters, 20 percent was ≥ 2 meters, and 4.6 percent was ≥ 3 meters deep. River channel fathometer depths recorded throughout the four day float trip are summarized. The maximum recorded water depth was 7 meters. The average of all maximum channel depths for the river pools surveyed was 3.6 meters. Deep pools were associated with every river bluff surveyed. The benefits and shortcomings of 1:60,000 scale aerial photography and 1:250,000 scale Side Looking Airborne Radar (SLAR) imagery, used as aids in this type of survey, are discussed.

INTRODUCTION

One hundred fifty two kilometers (94.4 miles) of the upper Colville River was floated by two individuals during the summer of 1979 with a twofold purpose. Raptor and aquatic habitat were assessed, during the four day float trip.

Pat Reynold's primary effort was directed toward surveying raptor habitat and nesting success. A total of sixty cliff nesting raptors were recorded along the 152 kilometers floated (Reynolds, 1980). This included one active peregrine falcon eyrie, one active gyrfalcon eyrie, nine active rough-legged hawk nests, and other nonpaired adult raptors. Other wildlife (i.e., bear, caribou, moose, and waterfowl) were sighted and recorded along the route. Faunal records for this trip are available from Pat Reynolds and her report on file at the Bureau of Land Management, NPR-A, Fairbanks District Office.

The author's primary purpose was to record water depth along the Colville River from which potential overwintering fish habitat could be assessed. Fathometer records were used for analyzing, documenting, and finally charting the locations of deep water habitat along the active river channel surveyed. Once the locations of deep water habitat were charted, these data were analyzed to determine the percentage of river with potential for fish overwintering areas verus shallow and riffle areas. In addition, the charted river depths were compared with remote-sensing data of this Colville River area to ascertain the applicability of utilizing aerial photography and/or Side Looking Airborne Radar (SLAR) imagery for some river depth determinations.

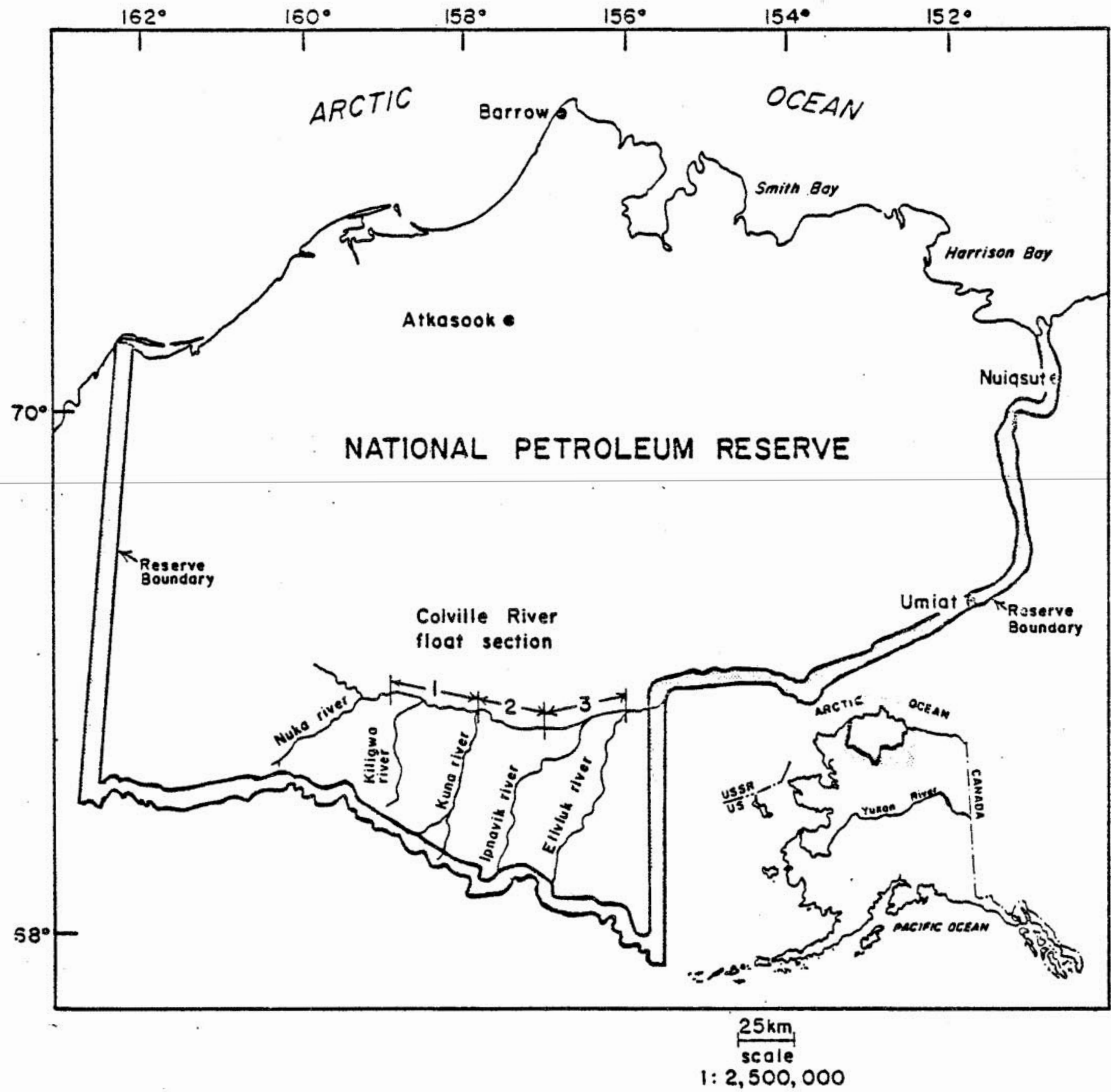

Figure 1, Location of Colville River float trip within The National Petroleum Reserve - Alaska.

The section of River surveyed was a series of pools separated by shallow riffles ($\leq$.3m). After freeze-up, free water in deep channels is present in winter pools below a growing ice sheet and between frozen shoals. Pools exceeding maximum winter ice thickness ($\approx$2m) are potential grayling overwintering areas. This species dominates the wintering habitat in the upper Colville River. Once depths are determined and deep versus shallow water habitat quantified, we can better estimate impacts from a specified action disturbing any river locality.

This survey started approximately 350 air kilometers from the mouth of the Colville, the largest of Alaskan arctic rivers. It began on the Colville half way between the confluence of the Nuka and Kiligwa Rivers (Fig. 1). The Nuka River was the only major tributary between the starting point and the headwaters of the Colville. The Kiligwa, Kuna, and Ipnavik Rivers were intersected during the float, with the trip terminating at the confluence of the Etivluk River.

The survey was accomplished in four days in a 12-foot Avon raft with a four horsepower, short-shaft outboard motor. The raft was sufficiently large to carry the two person party, food, fuel, camping, and depth sounding equipment. The outboard was only useful in the long river pools of slow moving water and had to be lifted for most riffles. Infrequently a riffle was shallow enough to require lining the raft across the rocks without passengers aboard.

A Model 206 Ranger Helicopter deposited us and gear approximately ten river miles above the confluence of the Kiligwa River on the afternoon of 26 July 1979. We were met by helicopter at the designated termination point at noon on the 30th of July at the confluence of the Etivluk and Colville Rivers. Progress along the river ranged from 2.3 to 5.8 kilometers per hour with an average of 3.3 km/hr. This average was fairly high considering it included all stops other than for making evening camp. There were no major mechanical problems and minimal sampling was done along the way. Slow progress was made early in the float trip due to little use of the outboard motor and frequent stops to hike along bluffs for raptor nest surveys. Progress was made at approximately 5.8 kilometers per hour during the very last day of the float when almost no stops were made because bluffs and nests were infrequent and the outboard motor was used as often as water depth permitted. Therefore, the speed or progress made on this last day was exceptionally good and should not be considered the average. Progress of about 15-20 kilometers per day is reasonable under similar circumstances, if some data acquistion is to be accomplished along the way.

METHODS

A Lowrance Model LRG-1510 portable, recording fathometer was installed on the raft with a 12 volt battery for power. The fathometer record could be annotated to reference record number, time, river location, or other observations necessary for later data reduction. The depth record accuracy was better than 0.1 meter. The fathometer depths had to be referenced to locations along the river to quantify river distance with a particular depth range. Depth ranges were easily identified on the fathometer record, but rigorous annotation and analysis were necessary to associate the depth ranges with locations and distances surveyed on the river. A concerted effort was made to standardize and maintain consistent fathometer record chart speed and down river raft velocity to simplify depth record/river distance and location interpretation. The slowest possible fathometer record chart speed was used thoughout the entire survey. The raft velocity was maintained by motoring through the long slow moving pools at about the same speed encountered without the outboard motor in the riffles and faster moving water between the deep pools. Although this was not an exact method, the cross checks on photographs and maps indicate that the precision was sufficient for the ensuing analysis.

For the purpose of data analysis, the Colville Survey was divided into three sections. During the first two sections, fathometer records were made intermittently, primarily of deep river channel. A continuous fathometer tracing was obtained of the last forty-nine kilometers of the survey.

Color infrared (CIR) aerial photographs at 1:60,000 scale and USGS 1:250,000 scale maps were used to keep track of fathometer record start and stop points and other observations during progress along the river. The 1:60,000 aerial photographs were absolutely essential for the type of survey undertaken. The photographs were stereo pairs covering the entire Colville River area floated. A small pocket stereo viewer was used to preview relief features encountered. The photographs also provided some preview of river channel characteristics. The most active river channel could be selected from the photographs, and changes in channel depths and direction could be anticipated. The photographs were of sufficient quality that changes in water color were used to predetermine riffles and in some cases to locate deep water within a large river pool. Therefore, the aerial photographs provided a valuable aid in river navigation for selection of a course that would provide fathometer records to best delinate maximum river channel depths in the most active river channel.

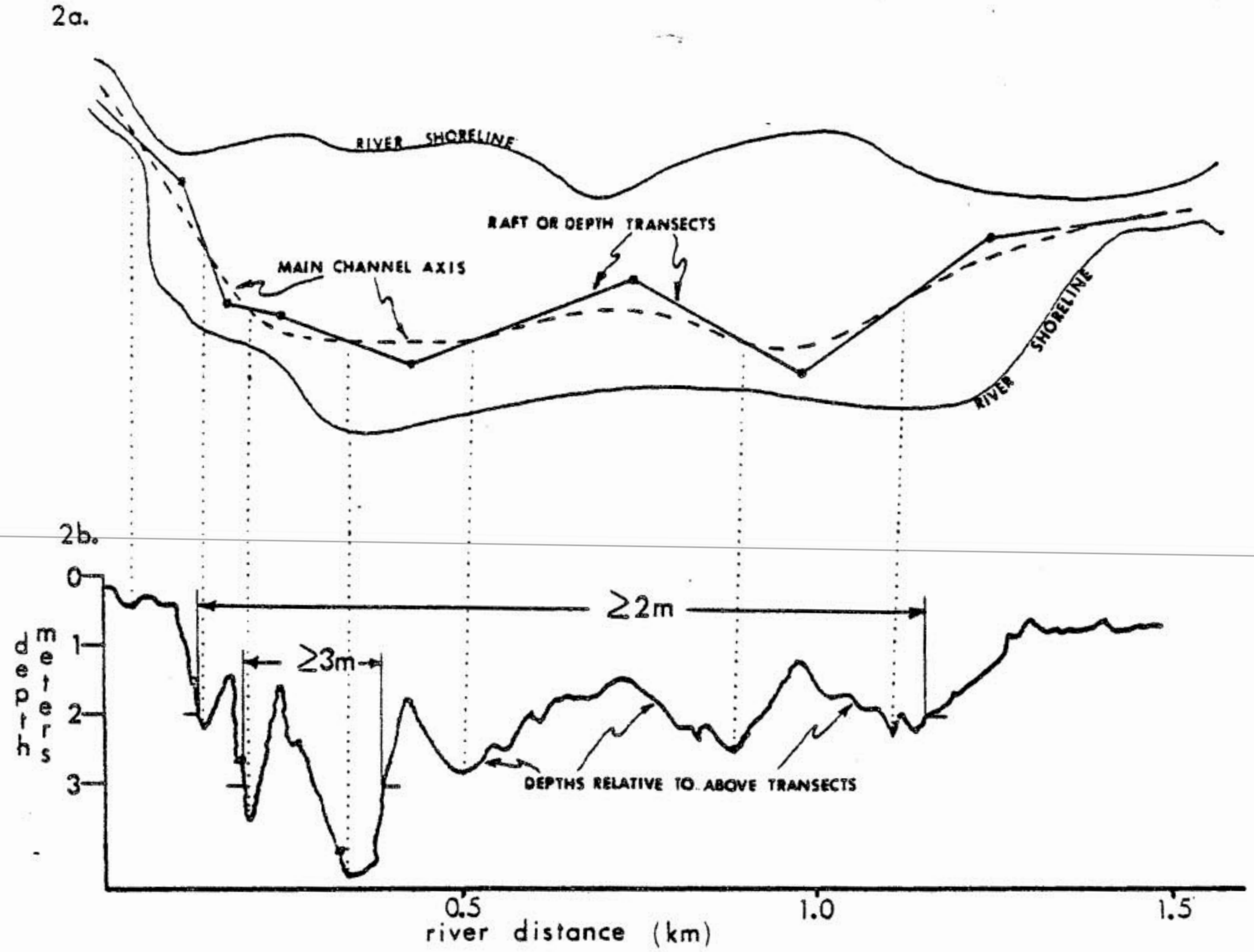

Figure 2. Illustration of raft navigation used to record depth and method used to interpret distances of river channel at or below 2 and 3 meters. [Top] a. Colville River pool with axis of deep channel (– – – –) and path of raft (transect, ———) defined. [Bottom] b. Depth from fathometer record relative to above transects and the resulting interpretation of channel distances at ≥2 and ≥3 meters.

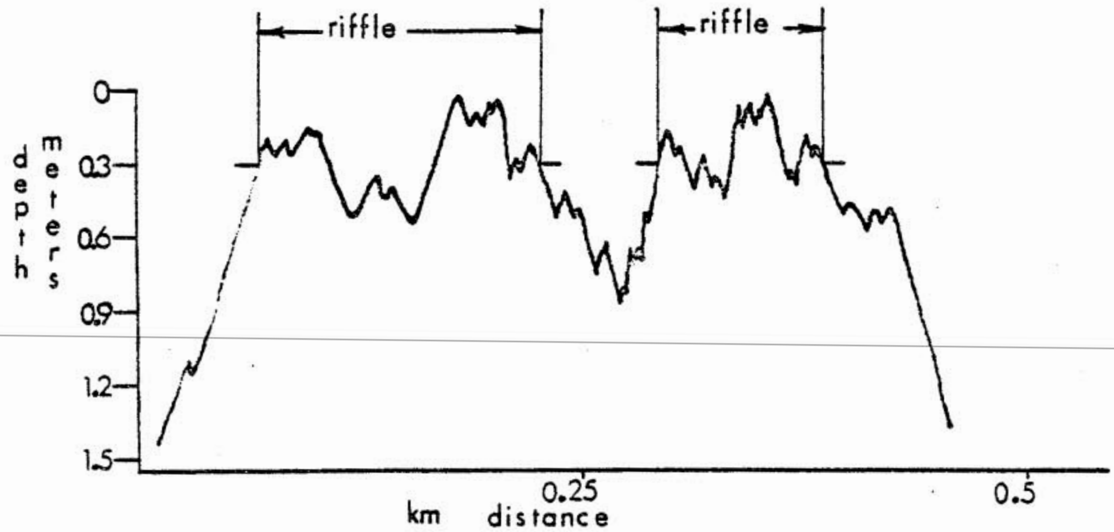

Figure 3. Illustration of fathometer record analysis/interpretation for riffles.

The deepest portion of a river channel cannot be defined with a single downriver transect, therefore, the main channel was navigated in an effort to best define the greatest depths in the axis of the channel. The raft and fathometer could not be kept over the deepest portion of the channel at all times, but was angled slightly across the channel until the channel axis was crossed and the river began to shoal. The raft was then turned toward the opposite shore to again recross the channel axis (Fig. 2a). Careful attention to the fathometer record depth changes and coordination with river course for best raft navigation provided a continuous series of down river transects that repeatedly crossed the main channel axis. These transects were used collectively to define river channel axis depth with careful analysis and interpretation, (Fig. 2b).

Maximum depths along the fathometer tracing showed where the transect intersected the main channel axis. Measuring between the point where a 2 meter depth was first encountered and where it was last encountered along the transect of a pool provided a conservative estimate of distance which is at or below 2 meters. Sections of the river at or below 3 meters were similarly calculated.

Riffles were measured in a similar manner. A riffle was defined specifically for this study to accommodate the peculiarities of the fathometer record. The beginning and termination points of a riffle were chosen to be .3 meter on the fathometer record. However, as long as the record did not indicate water depths exceeding .6 meter, between the .3 meter end points, the riffle was considered continuous (Fig. 3). These riffles were characteristically fast moving water, usually choppy over large cobbles or small bolders, in the stretches of river separating the large deep river pools.

Percentages were calculated of river distance with water depth range in the following categories: riffle, $\geq$2m, and $\geq$3m. The fathometer data for the last 49 kilometers of survey (Section 3) was most important because it was continuous data. The deep water habitat (i.e., $\geq$2m and $\geq$3m) was plotted on both 1:60,000 aerial photographs and a USGS 1:250,000 map.

Stereopairs of the aerial photographs were used to locate bluffs that intersected or were immediately adjacent to the river water's edge from which fathometer records were obtained. The focus was on those bluffs that were part of the riverbank or contributed sufficiently to the active channel course to be considered the causal factor contributing to the existing river channel morphology. Bluffs affect the river channel when they or the rubble from them restrict the river channel course.

A 1:250,000 scale map depicting deep water areas along the last 49 kilometers of the Colville Survey was compared with 1:250,000 scale Side Looking Airborne Radar (SLAR) imagery of the same Colville River area to see if any water depth/SLAR image correlation was evident. I hypothesized that bright SLAR images from the ice-covered Colville might occur at deep river locations where liquid water beneath the ice was assured. This SLAR image phenomenon has been documented for arctic lakes and in the Mackenzie River Delta (Campbell et al., 1975).

RESULTS AND DISCUSSION

Figure 4 shows the location of deep water areas (≥2m and ≥3) found along the three sections of the Colville River. Depicted on a 1:250,000 scale map, the data show deep pools surveyed in each section: 6 deep water areas were surveyed in Section 1, 9 deep water areas were surveyed in section 2 and 41 deep water areas were found with continuous survey in Section 3. Bluffs that occur as riverbanks along navigated river channels are also shown in Figure 4. The relationship between bluffs and deep water habitat is evident and is discussed later.

The water depth data is summarized in Table I for the sections of the entire 152 kilometer survey. The data in Section 3, the last 49 kilometers of the trip, are most significant in that the fathometer depths were continuously recorded for both deep and shallow areas of the river channel.

The maximum depths of the deep channels recorded ranged from 1.5 to 7.0 meters. The 7.0 meter depth was recorded while rafting Section 1 near the starting point. This upper section of river did not have as much water as it was prior to the confluence of the Kiligwa and Kuna Rivers, but it had larger bluffs with deep cut river channels adjacent to the bluffs. The maximum pool depth found in the last 49 kilometers, Section 3, was only 4.9 meters. The bluffs in this area were less frequent and appear to have less significant impact on the river channel course than those upriver in Sections 1 and 2. The average maximum pool depth for the entire area floated was 3.6 meters. An ice cover of 2 meters would still leave 1.6 meters of water beneath the ice for overwintering fish.

Table 1 also lists percentages of shallow versus deep water habitat calculated from the 49 kilometers of continuous fathometer records acquired throughout Section 3 of the survey. Twenty-three percent of this portion of the river was riffle or shoal where even a short shaft four horsepower outboard motor had to be lifted clear of the water to avoid propeller damage. Twenty percent was ≥2 meters, while only 4.6 percent as ≥3 meters in depth. This meant that in Section 3 only about one fourth of an area ≥2m had depths ≥3m. In Section 1 and 2 close to one half of the area within a pool ≥3m was

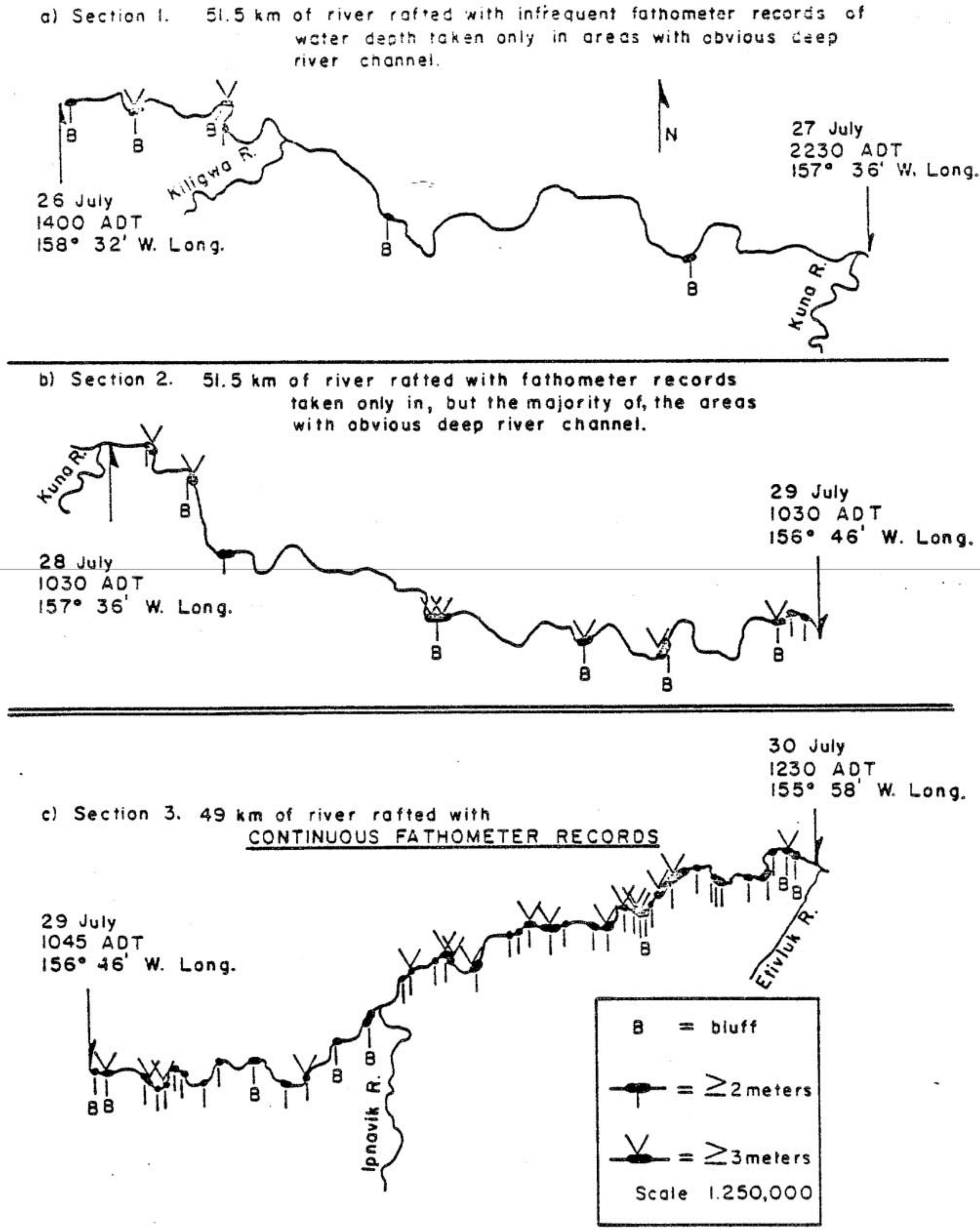

Figure 4. a.b.c. Colville River Float depicted in 3 contiguous sections with deep water channels, river bluffs, and major tributaries annotated.

Table 1. Water depth data along upper Colville River.

DESCRIPTION OF COLVILLE RIVER SECTIONS FLOATED	DISTANCE FLOATED (km)	LENGTH OF FATHOMETER RECORDS TAKEN (km)	RANGE OF MAXIMUM DEPTHS RECORDED (m)	RIFFLES RECORDED (km)	RIFFLES RECORDED (% of record)	≥2m DEPTH RECORDED (km)	≥2m DEPTH RECORDED (% of record)	≥3m DEPTH RECORDED (km)	≥3m DEPTH RECORDED (% of record)
SECTION 1: Fathometer equipment was tested along this upper river section. Although fathometer transects were few, bluff/raptor stops were frequent.	51.5	5.3	1.7 to 7.0	*1.1	21	*2.6	48	*1.3	24
SECTION 2: Fathometer records were more frequent. Depth transects were taken along many of the recognizable deep channels throughout this portion of the float.	51.5	9.5	1.5 to 5.9	*.1	1	*5.8	61	*2.2	24
SECTION 3: CONTINUOUS RECORDS were taken along this final section of the float. This was the first attempt to record both deep and shoal areas. Large bluffs and hence raptors were infrequent.	49	49	2.2 to 4.9	11.1	23	9.8	20	2.2	4.6
TOTALS and/or AVERAGES as specified for the entire float (152 km).	TOTAL 152	TOTAL 63.8	AVERAGE 3.6						

*Data was biased toward deep areas because noncontinuous records were taken primarily within deep channels.

$\geq$3m deep. Shallow areas with water depth slightly greater than a riffle yet less than 2 meters were not described in Table 1. However, this is the remaining percentage of the river excluding riffles and $\geq$2 meter areas. In Section 3, 57 percent of the river channel water depth was slightly greater than riffles yet less than 2 meters.

The 1:60,000 scale color infrared (CIR) photographs were essential for performing this study as previously discussed. Interpretation and analysis of river channel depths on the fathometer record were enhanced by the use of the aerial photographs. River pools with the deep channels could be differentiated from the narrower riffles with light colored shallow and/or choppy water. Some of the photograph characteristics that aided in placement of deep versus shoal areas were subtle or inconsistent (i.e., color of water, width and shape of river, presence or absence of river bars, and confluence of other water sources) while bluffs were obvious and a consistent indicator of deep water. Unfortunately, the photographs are too extensive to include in this report.

During the float, fathometer records were taken adjacent to 15 river bluffs. Table 2 shows the relationship between bluffs and deep water areas. Deep water channels were found off every bluff surveyed along the 152 kilometer survey. Of the 56 deep water ($\geq$2m) areas defined by fathometer records, 18 were associated with one of these bluffs. Therefore, 32 percent of the deep pools surveyed were associated with a river bluff. Only 20 percent of the deep pools were associated with bluffs in Section 3 (Table 2), but the bluffs were less frequent in this river section (Fig. 4). Every one (100 percent) of the 15 river bluffs surveyed had at least one deep ($\geq$2m) river channel area adjacent to it. Sixty-nine percent of these had water depths $\geq$3 meters. This association of bluffs with deep water areas has practical application. Stereopairs of the aerial photographs can be used for other areas of the river to find bluffs where deep water river habitat can be predicated to be present with reasonable confidence. Some care and judgment must be used to apply this indicator along the entire river. The following river and buff conditions effect the occurrence of deep water at bluffs: river gradient; bluff/river flow association; suspended sediment load; and bluff morphology and composition. When an active river channel is restricted by a resistant bluff face, river channel scouring results. The data in Figure 4 and Table 2 substantiate the resulting association of deeply scoured river channels adjacent to the bluffs surveyed.

Although the aerial photographs utilized were two years old (NASA, July 1977), the active river channel and bars observed appeared to be much the same configuration in the photographs as observed during the float trip in July 1979. During the 152 kilometers (km) of the river traversed, only two locations were observed where the main channel had changed. It had returned to a preexisting channel that had not been as

Table 2. Correlation between deep water areas and bluffs along upper Colville River.

RIVER SECTIONS	AVERAGE DISTANCE BETWEEN RIVER BLUFFS (km)	NUMBER OF DEEP AREAS, ≥2 m, RECORDED	NUMBER OF DEEP AREAS ≥2 m, ASSOCIATED WITH A BLUFF	NUMBER OF RIVER BLUFFS SURVEYED WITHOUT WATER DEPTHS ≥2 m	% OF DEEP AREAS, ≥2 m, ASSOCIATED WITH A BLUFF	% OF RIVER BLUFFS ASSOCIATED WITH DEEP AREAS, ≥2 m
SECTION 1:	4.3	6	5	0	83	100
SECTION 2:	4.0	9	5	0	56	100
SECTION 3:	8.2	41	8	0	20	100
	AVERAGE 5.5	TOTAL 56	TOTAL 18	TOTAL 0	AVERAGE 32	AVERAGE 100

active in July 1977. These two changes amounted to approximately 3 km of the 152 km floated. This is less than 2 percent change in river course for the two year period. We accomplished some ground verification of color changes noted in aerial photographs of gravel bars. The size and shape of river bars, as well as, pockets of sorted sand and gravel materials, within large river bars, were similar to those noted in the two year old photographs. The CIR aerial photographs also delineated existing river bar willow areas with very good clarity.

Section 3 of the Colville River (Fig. 4c) was imaged with SLAR five different times while ice-covered this past winter and once when ice-free this summer. Part of the purpose of this study was to determine if any correlation exists between deep water areas delineated in Figure 4c at 1:250,000 scale and the varying signal returns discernible on the 1:250,000 scale SLAR imagery. No significant correlation was found between the two. Freshwater arctic lakes not frozen to the bottom provide a high SLAR signal return delineating the zone of ice contact with the lake bottom (Weeks et al., 1978). Some plausible reasons for a bright return from lakes not yet frozen to the bottom versus no such differentiatable SLAR return from a river not frozen to the bottom are discussed below, but need additional research for verification. Colville River pool morphology, bottom material, pool size, and ice cover are physically different from that of lakes with the bright SLAR images. The river areas with liquid water beneath the ice are close to the minimum mapable unit for SLAR. The river bottom is composed of rock and gravel rather than the fine sand, silt, and organics found in the lakes. River ice forms from moving water unlike lake ice which forms from a stagnant body of water. The ice crystals (i.e., orientation and size) that form under these two different conditions are likely to be different.

Gas bubbles within river and lake ice were observed to be different. The gas bubble content of Colville River ice was checked within Section 3 on 26 November 1979. The river ice did not have the elongate, vertically oriented gas bubbles so common in all freshwater lake ice samples observed by the author over the past year. The differences in gas bubbles may be a significant factor in returning the SLAR signal, but additional work on all the above and possibly other parameters is necessary before any conclusion can be reached.

Unvegetated river bars are difficult to distinguish from river channels on the winter SLAR imagery. Summer imagery, when the river is ice-free, is best for differentiating the river bar from river channel. Some of the river bars had high signal returns which were very bright on the winter imagery. These were found to be feltleaf willow, Salix alaxensis, which matched willow stands on the summer CIR photography. The willows could easily be distinguished from unvegetated river bar and ice-covered river channel on the SLAR Images. The high return from these willows seems to be due to fall and winter retention of dead leaves on the willow branches. Willow leaves in the Section 3 area of the Colville were observed on 26 November 1979 to be dry, curled, and strongly attached to the stems. The curled leaves had dimensions of about 2-3cm width and 4-6cm length. These leaves, at or near the SLAR signal wave length (3cm), seem to reflect a high percentage of the signal, thus defining the willow stands on winter imagery. June and August imagery did not delineate willow areas nearly so well as did December, February, or April imagery. The willow leaves are probably shed during the late winter or early spring. The new, live and growing leaves seem to reflect less SLAR signal, than do the dry curled ones.

SLAR imagery from anytime of year is useful for depicting bluff and other relief features. However, the SLAR flight direction relative to the direction of the bluff face must be taken into consideration as all the bluffs are not imaged equally well. The bluff faces parallel to or facing away from the radar signal will not be imaged nearly so well as those facing the radar signal.

The 1:250,000 scale SLAR is too small to provide the resolution necessary for discrimination of detailed riverine habitat. Even the 1:60,000 CIR aerial photographs are inadequate for detailed riverine habitat studies, but proved to have adequate detail and be essential auxiliary data for this study.

Some angling was done during the four day float trip. Most of the fishing effort was unrewarded. Most fishing was done at the confluence of creeks and rivers or near deep channels encountered. Only one grayling 38 cm long was taken from the Colville during this raft trip. This one was taken at the confluence of the Kiligwa River. Several grayling were caught in the Ipnavik River within a mile of its confluence with the Colville River. Suspended sediment load in the Colville River water was fairly low during the raft trip. The river bottom could be seen through up to 1.5 to 2.0 meters of water.

SUMMARY

River channel water depths were surveyed in the Upper Colville River. Twenty three percent of the river was riffle. Fifty seven percent of the river channel length was of intermediate depth between riffle and 2 meters. Twenty percent was greater than or equal to 2 meters in depth, while only 4.6 percent of the channel was greater than or equal to 3 meters in depth. Deep water ($\geq$2m) existed adjacent to every bluff surveyed on the river. The maximum water depth recorded was 7 meters. An average maximum channel depth of 3.6 meters was calculated.

Aerial photography at 1:60,000 scale of the river was an invaluable aid in this survey. SLAR imagery at 1:250,000 scale of the same area was found to be of little or no value for delineating deep river channel areas.

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OPEN FILE REPORTS

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